MOBILE MULTIMEDIA COMMUNICATIONS

FINAL REPORT

CONTRACT DCA100-91-C-0031

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1 INTRODUCTION

This document summarizes work performed by Delta Information Systems, Inc. (Delta) for the National Communications Systems (NCS), Office of Technology and Standards. The NCS is responsible for the management of the Federal Telecommunications Standards Program, which develops telecommunications standards, whose use is mandatory for all Federal departments and agencies.

This document is a final report for a Task Order on Contract DCA100-91-C-0031. The titles for the contract and Task Order are listed below.

Contract DCA100-91-C-0031
Development of Federal Telecommunication Standards Relating to Digital Facsimile and Video Teleconferencing

Task No. 2
Technical Work in the Area of Video Teleconferencing

Subtask No. 2
Mobile Multimedia Communications

Video TeleConferencing (VTC) is being widely deployed throughout the federal government, achieving great benefits in productivity and timeliness of decisions. The deployment has resulted from the maturity of video teleconferencing standards, the primary example being the H.320 series of ITU Recommendations.

The ITU has recently completed the new H.324 set of standards to enable video conferencing over the PSTN [Public Switched Telephone Network]. This new H.324 terminal will bring a whole new set of capabilities and facilities to the federal government community. Typical new applications include telecommuting, disaster recovery, surveillance, and the ability for federal workers to easily access each other on a global basis. The ITU is also working on a new set of standards [H.324M] which will adapt the H.324 Recommendations from the PSTN for use on the mobile network environment. This set of mobile VTC standards, which is due for completion in 1996, will open up an entire new dimension of telecommunications for the federal government community. One issue which should be noted is that VTC, whether it be mobile or otherwise, does not require motion video to be part of the transmission. The H.324 and H.324M standards define multimedia terminals which provide for any combination of speech, data, and video communications. These terminals provide for interactive conversational services as well as non-conversations services such as the access of information [e.g. computer graphics, documents, still pictures, motion video] from data bases.

The purpose of this report is to summarize that status of the development of mobile video teleconferencing and interpret the relevance of this work to the federal government community. The report is divided into four main parts. Section 2.0 contains a review of all wireless networks which could potentially be used for the video conferencing application. Mobile networks which are discussed include cellular [both analog and digital], cordless, wireless LANs, satellite, and FPLMTS [Future Public Land Mobile Telecommunications System]. In Section 3.0 there is a discussion of the standards which are relevant to mobile video conferencing. First, there is a presentation of the H.324 standard which is the basic architecture of the mobile multimedia terminal. Next the status of H.324M, the extension of H.324 to mobile networks, is presented. Other items include standards related to data base access as well as long term standards investigations which are underway.

The status of the development of wireless multimedia terminals is discussed in Section 4.0. The types of terminals covered include work accomplished in the European community, transmission via the analog AMPS network, terminals based on portable general purpose computers [notebooks, PDA's, etc.], and special purpose devices. Section 5.0 contains a review of the potential applications of wireless VTC in the federal government. Uses include teleconferencing, emergency/disaster relief, telemedecine, law enforcement, remote maintenance/ diagnostics, and surveillance. Finally conclusions and recommendations are provided in Section 6.0.

2 WIRELESS NETWORKS

Wireless networks can be classified according to the size of the zone they serve; [1] Global/national, [2] Mobile [town, highway], [3] Local [shopping mall], [4] Indoor/LAN. Table 2-1 is a summary of the key characteristics of these four types of wireless networks. Mobile networks dominate wireless communications today with approximately 13 million subscribers in the United States. Although most prevalent wireless networks in use today are analog, and voice oriented [e.g. the AMPS-Advanced Mobile Phone service], there is a great deal of work going on in the digital wireless area. Again, much of the digital wireless work remains focused on voice communications [GSM in Europe, IS-54 in the U.S., JDC in Japan].

Table 2-1

	Global/National	Mobile	Local	WL/LAN
Terminal Location	Anywhere	Vehicle, Urban, Suburban	Shopping mall, transportation	In building
Cell Range	Hundreds of Miles	1-20 mi.	< 1 mi.	Hundreds of feet
Cell Descriptor	Megacell	Macrocell	Microcell	Pico cell
Bit Rate	Low	ó 19.2 Kbps	Medium	High

Mobility

High speed
vehicle
Low speed
Low

Example
Iridium
Analog - AMPS
Digital -
Future - PCS
Analog - Cordless

2.1 Cellular

2.1.1 Analog Cellular System

Cellular radio can be regarded as the earliest form of wireless "personal communications." It allows the subscriber to place and receive telephone calls over the wireline telephone network wherever cellular coverage is provided. All of these "first-generation" cellular systems use analog frequency modulation (FM) for speech transmission and frequency shift keying (FSK) for signaling. Individual calls use different frequencies. This way of sharing spectrum is called frequency division multiple access (FDMA).

The distinguishing feature of cellular systems compared to previous mobile radio systems is the use of many base stations with relatively small coverage radii, on the order of 10 km or less.

In cellular systems, continuous coverage is achieved by executing a "handoff" (the seamless transfer of the call from one base station to another) as the mobile unit crosses cell "boundaries." This requires the mobile to change frequencies under control of the cellular network. The U.S. standard for analog cellular is known as AMPS (Advanced Mobile Phone Service), and there are now 8 million AMPS subscribers.

2.1.2 Digital Cellular Systems

The development of low-rate digital speech coding techniques and the continuous increase in the device density of integrated circuits (i.e., transistors per unit area), have made completely digital second-generation cellular systems viable. Digitization allows the use of time division multiple access (TDMA) and code division multiple access (CDMA) as alternatives to FDMA. With TDMA, the usage of each radio channel is partitioned into multiple timeslots, and each user is assigned a specific frequency/timeslot combination. Thus, only a single mobile in a given cell is using a given frequency at any particular time. With CDMA (which uses direct sequence spreading), a frequency channel is used simultaneously by multiple mobiles in a given cell, and the signals are distinguished by spreading them with different codes.

2.1.2.1 IS-54 in North America

In the U.S., the Electronic Industries Association (EIA) and the Telecommunications Industry Association (TIA) have adopted the IS-54 digital cellular standard based on TDMA. IS-54 retains the 30 KHz channel spacing of AMPS to facilitate evolution from analog to digital systems. Each user channel is allocated 16 Kbps; 3 Kbps for control and 13 Kbps for speech including error control.

Since systems using the IS-54 standard must operate in the same spectrum used by the existing AMPS systems, the IS-54 standard is "dual mode," meaning that it provides for both analog (AMPS)and digital operation. This is necessary to accommodate "roaming" subscribers, given the large embedded base of AMPS equipment. Although service providers have already begun to deploy IS-54 equipment in major metropolitan areas in the United States, the conversion to digital will be slower in less dense areas. Consequently, there will be a mix of analog and digital terminals as well as base station equipment for a considerable period of time.

2.1.2.2 IS-95 in North America

The EIA/TIM IS-95 standard is based on the CDMA system. With IS-95, many users share a common channel for transmission. The basic user channel rate is 9.6 kb/s. This is spread to a channel chip rate of 1.2288 Mchip/s (a total spreading factor of 128) using a combination of techniques. Each mobile in a given cell is assigned a different spreading sequence, providing perfect separation among the signals from different users, at least for a single-path channel. At both the base station and the mobile, RAKE receivers are used to resolve and combine multipath components, significantly reducing the fading amplitude.

Like IS-54, IS-95 is compatible with the IS-41 signaling protocol, and is a dual-mode standard designed for the existing North American cellular bands; IS-95 terminals can operate either in the CDMA mode or the AMPS mode. Deployment of IS-95 systems in the Los Angeles, California area is expected this year.

2.1.2.3 PCS (Personal Communication System)

In the U.S., the FCC has taken the initiative to arrange for the development of PCS. Based on this work, it is anticipated that some PCS capability may be fielded toward the end of 1995.

On September 23, 1993, the U.S. FCC authorized the use of spectrum in the 1850 to 2200-MHz "Emerging Technologies" band for wideband personal communications (often referred to as the "2 GHz" band). The plan was modified on June 9, 1994 to focus on the 1850-to-1990-MHz band. The FCC allocated a total of 120 MHz for licensed PCS at 1850 to 1910 MHz and 1930 to 1990 MHz. Unlicensed PCS is allocated 20 MHz at 1910 to 1939 MHz. The key wireless system interfaces for which standards are being developed are: between the radio terminal and the access system (the "air" interface), between the radio access system and the switch, between the switch and the database, and between PCS systems.

Work on PCS standards is underway at both the national and international level. In the United States, three voluntary standards organizations -- Committee T1, the Telecommunications Industry Association (TIA) and IEEE (through standards committees such as 802.11), all accredited by the American National Standards Institute (ANSI) -- are jointly and separately developing various standards and reports which will influence and guide the deployment of PCS systems in the United States.

Committee T1 is organized into six Technical Subcommittees (TSC). The primary focus for PCS standards is TSC T1P1, which was formed in 1990 and has responsibility for service descriptions, system and service objectives, privacy and authentication, architecture and air interface standards, as well as overall Program Management for PCS standards development. T1S1 is developing signaling protocols to support PCS, and T1A1 has developed transmission performance guidelines for speech and voiceband data. A standard for the operation, administration, maintenance and provisioning (OAM&P) of PCS systems has been developed in T1M1. Currently, the TSCs in T1 are cooperatively working on the development of complete service descriptions and signaling protocols for basic, bearer, and supplementary services.

TIA is organized into four divisions, each of which has several associated Engineering Committees responsible for standards development. In the Mobile & Personal Communications Division, wireless standards are developed for 2-GHz PCS, 800-Mhz cellular, 900-Mhz specialized mobile radio and 46/49 and 900-Mhz cordless. The focus for 2-GHz PCS standards is Engineering Committee TR46, which was formed in early 1993. Within TR46 are four subcommittees that address PCS services and network reference models, system and network interfaces, networking signaling, air interfaces, and privacy and authentication.

TR46 works closely with Committee T1 through a Program Management team (PMT) to coordinate joint activities and to avoid duplication of effort. The PMT has issued a comprehensive plan for PCS standards development. In 1992 T1P1 and TR46 formed a unique structure, the Joint Technical Committee (JTC) on Wireless Access, to combine the two groups' expertise in order to develop a common set of air interface standards for the licensed and unlicensed portions of the 2-GHz band. The TJTC consists of Working Group T1P1.4 and Task Group TR46.3.3. The JTC's mission is to develop standards and technical reports concerning user access to telecommunications networks through interfaces associated with wireless services and PCS. The JTC is an innovation in the cooperative activities of Committee T1 and TIA, which reduces duplicative activity and meets industry needs.

In March 1994, technical ad-hoc groups (TAGs) were organized for seven PCS proposals. Table 2-2, taken from a presentation given at the National Engineering Consortium WPC Teleforum III, provides a brief summary of some of the technical characteristics of these interfaces.

Table 2-2 Summary of Technical Characteristics

TAG-1
TAG-2
TAG-3
TAG-4
TAG-5
TAG-6
TAG-7

Parameter
New
15-95-Based
PACS

15-54-based
DCS-based
DCT-based
W-CDMA

Access Method
CDMA/TDMA/FDMA
CDMA
TDM/TDMA
TDM/TDMA
TDMA
TDMA
D-CDMA

Duplex Method
TDD
FDD
FDD
FDD
FDD
TDD
FDD

Bandwidth
5 MHz
1.25MHz
300kHz
30kHz
200kHz
1728kHz
5MHz

Bit rate (no overhead)
32 kb/s
8/13.3 kb/s
32 kb/s
7 kb/s
13 kb/s
32 kb/s
32 kb/s

Process gain
21 dB
21 dB
NA
NA
NA
NA
21 dB

Channel spacing
5 MHz
1.25 MHz
200 kHz
30 kHz
200 kHz
1728 kHz
5 MHz

Voice channels/carrier 32
(8kb/s CELP)
SHO = soft handover
20 (eff) + SHO
8
3
8
12
128 (less
SHO)

Reference to AMPS
16X
10X
0.8X
3X
2-3X
0.2X
16X (less
SHO)

Modulation
Cont. Ph.
Shift QM
PQPSK/QPSK
Pi/4 d-QPSK
GMSK
GFSK
PQPSK/QPSK

Error control (voice)
None
FEC
None
FEC
FEC
None

FEC

Frequency Reuse (N)
3
1
16X1
7X3
7X1 and
3X3
9
1

Max. avg. subscriber power
-
200 mW
12.5 mW
100 mW
125 mW
20.8
500 mW

SU power in timeslot
1W
-
100 mW
600 mW
1 W
250 mW

Time frame length
625 ms
-
312.5 ms
6.7
577 ms
417 ms

Timeslot length
80 ms
50 ms
9 ms
110 ms
90 ms
28 ms
13.25 ms

End-to-end speech delay
80 ms
50 ms
9 ms
110 ms
90 ms
28 ms
13.25 ms

Equalizer
No
No
No
Yes
Yes
No
No

Vocoder
CELP (8 kb/s)
ADPCM
(16, 25, 32, 50 kb/s)
Var. rate
(8/4/2/1)
ADPCM
(32 kb/s)
VSELP
(8kb/s)
LDCELP (16 kb/s)
RPE-LTP
(13 kb/s)
ADPCM
(16-32 kb/s)
ADPCM
(32 kb/s)

Source: taken from a presentation give at the National Engineering Consortium WPC Teleforum III [9].

To minimize political influences, the JTC has associated the activities of the TAGs with technologies rather than company proposals. The proposals can be characterized as follows:

TAG-1 (new): a composite 5 MHz CDMA/TDMA/FDMA air interface for large cell licensed-band applications, and small-cell, unlicensed-band applications. The basis of this proposal is derived from technology that resulted in the FCC awarding a "Pioneer's Preference" to Omnipoint Corporation.

TAG-2 (IS-95-based): a 1.25-MHz CDMA air interface for large cell applications.

The basis of this proposal is derived from the 800-MHz Cellular EIA/TIA Interim Standard, IS-95.

TAG-3 (Personal Access Communications System, or PACS): an eight-timeslot TDMA air interface with an FDD mode for small cell licensed-band applications and a TDD mode for small-cell, unlicensed-band applications. The basis of this proposal is derived from Wireless Access Communications System (WACS) developed by Bellcore, and Personal Handy Phone developed in Japan.

TAG-4 ((S-54 based): a three-timeslot TDMA air interface for large-cell, licensed-band applications. The basis of this proposal is derived from the 800 MHz Cellular EIA/TIA Interim Standard, IS-54.

TAG-5 (DCS-based): an eight-timeslot TDMA air interface for large-cell, licensed-band applications. The basis of this proposal is derived from DCS 1800, which is a frequency shifted derivative of GSM. GSM is a widely deployed European Cellular System developed by ETSI.

The proposal has the potential of adding timeslot aggregation capabilities to support higher data rates. Multiple vocoders are supported. The proposal is essentially the same as DCS 1800 systems currently deployed in Europe.

TAG-6 (DCT-based): a 12-timeslot TDMA air interface for small-cell, licensed-band applications. The basis of this proposal is derived from Digital European Cordless Telephone (DECT).

The proposal is essentially the same as existing DECT systems in Europe, and appears to work well in office and indoor environments. Modifications are being considered to make the interface more viable outdoors. The proposal will comply with the spectrum etiquette for operation in the unlicensed PCS band.

TAG-7 (W-CDMA): a 5-MHz CDMA air interface for large- and small-cell licensed-band applications. The basis of this proposal is derived from wideband CDMA technologies of OKI and InterDigital.

The proposal is looking at the feasibility of noise cancellation techniques to further increase the capacity of CDMA systems. It also supports flexible aggregation of traffic channels within an RF channel to support higher data rates.

It is useful to divide the PCS proposals into two broad categories--high-tier and low-tier. High tier basically refers to "cellular" systems which are characterized by high power, voice communications, mobile vehicular applications, and relatively low bit rate. Table 2-3 provides information on four high-tier systems three of which are TAG-2, TAG-4, and TAG-5 [IS-95, IS-54, and GSM respectively]. The low-tier systems are characterized below, and several examples are listed in Table 2-3 including the TAG-3 and TAG-6 systems [WACS/PACS, and DECT respectively].

32 kb/s ADPCM speech encoding to take advantage of the low complexity and low power consumption, and to provide low-delay high-quality speech.

Flexible radio link architecture that will support multiple data rates from several kb/s to several hundred kb/s.

Low transmitter power (ó 25 mW average) with adaptive power control to maximize talk time and data transmission time.

Low complexity signal processing to minimize power consumption. Complexity one-tenth that of digital cellular or high-tier PCS technologies is an objective.

Low co-channel interference and high coverage area design criteria. In order to provide high-quality service over a large region, at least 99 percent of any covered area must receive good or better coverage, and be below acceptable co channel interference limits. This implies less than 1 percent of a region will receive marginal service. This is an order-of-magnitude higher service requirement than the ten percent of a region permitted to receive marginal service in vehicular cellular system (high-tier PCS) design criteria.

Such technologies and systems have been designed, prototyped, and laboratory-and field-tested and evaluated for several years. This dual-tier viewpoint is consistent with the progress in the Joint Technical Committee (JTC) of the U.S. standards bodies, Telecommunications Industry Association (TIA) and Committee T1 of the Alliance for Telecommunications Industry Solutions (ATIS). Many technologies and systems were submitted to the JTC for consideration for wireless PCS in the new 1.9 GHz frequency bands for use in the United States. It was evident that there were at least two, and perhaps three distinct different classes of submissions.

One class of submissions was the group labeled High Power Systems, Digital Cellular (High-Tier PCS) in Table 2-3. They are highly optimized for low bit-rate voice, and therefore have somewhat limited capability for serving packet-data applications. There are more than 100 million vehicles in the United States alone. In the future, most, if not all, of these will be equipped with high-tier cellular mobile phones. Therefore, there will be a continuing and rapidly expanding market for high-tier systems.

Another class of submissions to the JTC including the Japanese Personal Handiphone System (PHS), and a technology and system originally developed at Bellcore, but carried forward to prototypes, and submitted to the JTC, by Motorola and Hughes Network Systems. This system was known as Wireless Access Communications System (WACS). These two submissions were so similar in their design objectives and system characteristics that, with the agreement of the delegations from Japan and the United States, the PHS and WACS submissions were combined under a new name, Personal Access Communication Systems (PACS), that was to incorporate the best features of both. This advanced, low-power wireless access systems, PACS, was to be know as low-tier PCS.

Table 2-3 Wireless PCS Technologies

High Power Systems
Digital Cellular (High Tier PCS)
Low Power Systems

Low Tier PCS
Digital Cordless

System
IS-54
IS-95 (DS)
GSM
DCS-1800
WACS/
PACS
Handi-Phone
DECT
CT-2

Multiple Access
TDMA/FDMA
CDMA/FDMA
TDMA/
FDMA
TDMA/
FDMA
TDMA/
FDMA
TDMA/
FDMA
TDMA/
FDMA
FDMA

Fre. band (MHz)
Uplink (MHz)
Downlink (MHz)
869-894
824-849
(USA)
869-894
824-849
(USA)
935-960
890-915
(Eur.)

1710-1785
1805-1880
(UK)
Emerg.
Tech'
(USA)
1895-
1907
(Japan)
1880-
1900
(Eur.)
864-868
(Eur. and
Asia

FR Ch. spacing
Downlink (KHz)
Uplink (KHz)

30
30

1250
1250

200
200

200
200

300
300
300

1728

100

Modulation
ã/4 DQPSK
BPSK/QPSK
GMSK
GMSK
ã/4 QPSK
ã/4
DQPSK

GFSK
GFSK

Portable Txmit
Power, max/avg
600 mW/
200 m/W
600 m/w

1 W/
125 mW
1 W/
125 mW
200 mW/
25 m/W
80 mW/
10 mW
250 mW/
10 mW
10 mW/
5 mW

Speech coding
VSELP
QCELP
RPE-LTP
RPE-LTP
ADPCM
ADPCM
ADPCM
ADPCM

Speech rate (kb/s)
7.95
8 (var.)
13
13
32/16/8
32
32
32

Speech ch/FT ch.
3
-
8
8
8/16/32
4
12

1

Ch. bit rate (kb/s)
Uplink (kb/s)
Downlink(kb/s)

48.6
48.6

270.833
270.833

270.833
270.833

384
384
384

1152

72

Ch. coding

« rate
conv.
« rate fwd.
1/3 rate rev
« rate
conv.
« rate
conv.
CRC
CRC
CRC
(control)
None

Frame (ms)
40
20
4.615
4.615
2.5
5

10
2

*Spectrum is 1.85 to 2.2 Ghz allocated by the FCC for emerging technologies; DS is direct sequence

In the JTC, submissions for PCS or DECT and CT-2 and their variations are also lumped under the class of low-tier PCS, even though these advanced digital cordless telephone technologies were somewhat more limited in their ability to serve all of the low-tier PCS needs.

2.2 Cordless Telephony

2.2.1 First-Generation Analog Cordless

Since 1984, analog cordless telephones in the United States have operated on ten frequency pairs in the bands 46.6-47.0 MHz (base transmit) and 49.6-59.0 MHz (handset transmit). The allowed emission bandwidth is 20 KHz, and the effective radiated power (ERP) is very low, roughly 20 W (compared to 10 mW for most other cordless telephone systems). Analog FM is used for the voice signal, and the U.S. Federal Communications Commission (FCC) rules require digital coding of the signaling functions for security. There are an estimated 60 million 46/49 KHz cordless telephones in use in the United States, and total sales are roughly 15 million units per year. Despite the recent availability of higher-power digital cordless telephones operating in the 915 MHz Industrial, Scientific, and Medical (ISM) band, the popularity of 49 MHz analog cordless telephones is expected to continue for a considerable time due to their low cost (U.S. $50 to $100 is typical for a basic unit).

Because of the large embedded base of these devices, the existing ten channel pairs have become inadequate, particularly in high-density areas. In August 1992, the TIA petitioned the FCC to make 15 additional frequency pairs near 44 MHz (base transmit) and 49 MHz (handset transmit) available for cordless telephones. In August 1993, the FCC adopted a Notice of Proposed Rule Making (NPRM) in response to TIA's petition, proposing specific provisions to be added to the FCC Rules. A final ruling on the new frequencies by the FCC is expected this year.

In the United States, Bell Communications Research (Bellcore) developed an air interface for Wireless Access Communications Systems (WACS). This interface is intended to provide wireless connectivity to the local exchange carrier (LEC), and is designed with low-speed portable applications and small-cell systems in mind. Base stations are envisioned as shoebox-sized enclosures mounted on telephone poles, separated by about 600 m. The WACS air interface is similar to the digital cordless interfaces, with two notable exceptions: frequency-division duplexing (FDD) is used rather than time division duplexing (TDD), and greater effort has been made to optimize the link budget and frequency reuse.

As part of the standards process in the United States related to the recently-allocated spectrum near 2 GHz for Personal Communications Services (PCS),
attributes of WACS and PHS have been combined to create an industry standard proposal for Personal Access Communications Services (PACS). PACS is intended as a "low-tier" air interface for the licensed portion of the new 2-GHz spectrum.

2.2.2 Digital Cordless Compared to Digital Cellular

From the foregoing summaries of the various digital cordless air interfaces, it is clear that while there are significant differences among them, they have a number of characteristics in common which distinguish them from the digital cellular technologies discussed earlier. In general, the digital cordless systems are optimized for low-complexity equipment and high-quality speech in a quasi-static environment (with respect to user mobility). Conversely, the digital cellular air interfaces are geared toward maximizing bandwidth efficiency and frequency reuse in a macrocellular, high-speed fading environment. This is achieved at the price of increased complexity in the terminal and base station. As summarized in Table 2-4, the physical layer parameters for digital cordless and digital cellular technologies reflect these respective design objectives.

Table 2-4   General Comparison of Digital Cordless and Digital Cellular Air Interfaces

CHARACTERISTICS	Digital Cordless	Digital Cellular
Cell size	small (50 to 500 m)	large (0.5 to 30 km)
Antenna elevation	low (15m or less)	high (15m or more)
Mobility speed	low (6kph or less)	high (up to 250 kph)
Coverage	zonal	wide-area continuous
Handset complexity	low	moderate
Base complexity	low	

high

Spectrum access
shared
exclusive

DESIGN ATTRIBUTES

Handset TX power (average)
5 to 10 mW
100 to 600 mW

Duplexing
TDD*
FDD

Speech coding
32kb/s ADPCM
8 to 13 kb/s vocoder

Error control
CRC
FEC/interleaving

Detection
discrim/differential*
coherent/differential

Multipath mitigation
antenna diversity (opt.)
diversity/equalizer/Rake

* PACS uses frequency duplexing and coherent detection.

2.3 Wireless LANs

Wireless local-area data networks (WLANs) can be characterized as providing low-mobility high-speed data communications within a confined region, e.g., a campus or a large building. Coverage range from a wireless data terminal is short, tens to hundreds of feet, like cordless telephones. Coverage is limited to within a room or to several rooms in a building. WLANs have been evolving for a few years, but overall, the situation is chaotic, with many different products being offered by many different vendors. There is no stable definition of the needs or design objectives for WLANs, with data rates ranging from hundreds of kb/s to more than 10 MB/s wireless link rates. An IEEE standards committee, 802.11, has been attempting to put some order into this topic, but their success has been somewhat limited. A partial list of some advertised products is given in Table 2-5. Users of WLANs are not nearly as numerous as the users of more voice-oriented wireless systems. Part of the difficulty stems from these systems being driven by the computer industry that views the wireless system as just another plug-in interface card, without giving sufficient consideration to the vagaries and needs of a reliable radio system.

Table 2-5 Partial List of WLAN Products

Product
Company
Location
Freq.
(MHz)
Link rate
User rate
Protocol (s)
Access
No. of chan or
spread factor
Mod./coding
Power
Network
topology

Altair Plus II
Motorola
Arlington Hts., IL
18-19 Ghz
15 Mb/s
5.7 Mb/s
Ethernet

4-level FSK
25 mW
peak
Eight
devices/radio;radio to base
to Ethernet

WaveLAN
NCR/AT&T
Dayton, OH
902-928
2 Mb/s
1.6 Mb/s
Ethernet-like
DS SS

DQPSK
250 mW
Peer-to-peer

AirLAN
Solectek
San Diego, CA
902-928

2 Mb/s
Ethernet
DS-SS

DQPSK
250 mW
PCMCIA
w/ant;radio to
hub

Free[prt
Windata Inc.
Northboro, MA
902-928
16 Mb/s
5.7 Mb/s
Ethernet
DS SS
32 chips/bit
16 PSK
trellis coding
650 mW
Hub

Intersect
Persoft Inc.
Madison, WI
902-928

2 Mb/s
Ethernet,
token-ring
DS SS

DQPSK
250 mW
Hub

LAWN

O'Neill Comm
Horsham, PA
902-928

38.4kb/s
AX.25
SS
20
users/chan.;
max 4 chan.

20 mW
Peer-to-peer

WiLan
WiLan Inc.
Calgary, Alberta
902-928
20 Mb/s
1.5
Mb/s/chan
Ethernet,
token ring
CDMA/
TDMA
3 chan.
10-15 links
each
"unconventional"
20 mW
Peer-to-peer

RadioPort
ALPS Electric
USA
902-928

242kb/s
Ethernet
SS
?/3 channels

100 mW
Peer-to-peer

ArLan 600
Telesys. SLW
Don Mill, Ont.
902-928
2.4 GHz

1.35 Mb/s
Ethernet
SS

1 W max
PCs with ant.;
radio to hub

RadioLink
Cal. Microwave
Sunnyvale, CA
902-928
2.4 GHz
250 kb/s
64 kb/s

FH SS
250 ms/hop
500 kHz space

Hub

Range LAN
Proxim, Inc.
Mountainview, CA
2.4 GHz
1Mb/s/
adaptor

Ethernet
token ring
DS SS
3 chan.

100 mW

Range LAN2
Proxim, Inc.
Mountainview, CA
2.4GHz
1.6 Mb/s
50 kb/s max
Ethernet
token ring
FH SS
10 chan @ 5
kb/s; 15 sub-ch. each

100 mW
Peer-to-peer
bridge

Netwave
Xircom
2.4GHz
1 Mb/s/
adaptor

Ethernet
token ring
FH SS
81 1 MHz
chan. or
"hops"

Hub

Freelink
Cabletron Sys.
Rochester, NJ
2.4 and
5.8 GHz

5.7 Mb/s
Ethernet
DS SS
32 chips/
bit
16 PSK
trellis coding
100 mW
Hub

There are two overall network architectures pursued by WLAN designers. One is a centrally coordinated and controlled network that resembles other wireless systems. There are base stations in these networks that exercise overall control over channel access. The other type of network architecture is the self organizing and distributed controlled network where every terminal has the same function as every other terminal, and networks are formed ad-hoc by communications exchanges among terminals. Such ad-hoc networks are more like citizen band (CB) radio networks, with similar expected limitations if they were ever to become very widespread. Nearly all WLANs in the United States have attempted to use one of the ISM frequency bands for unlicensed operation under part 15 of the FCC rules. These bands are 902 to 928 MHz, 2400 to 2483.5 MHz, and 5725 to 5850 MHz, and they require users to accept interference from any interfering source that may also be using the frequency.

2.4 Mobile Satellite Services

There are some situations in which providing radio coverage with cellular-like terrestrial wire-less networks is either not economically viable (such as in remote, sparsely-populated areas), or physically impractical (such as over large bodies of water). In these cases, mobile satellite services (MSS) could fill the gap, allowing complete global coverage. Spectrum has been designated by the ITU for MSS, and there are many MSS systems in various stages of concept, design, and operation. Some support only data services while others accommodate voice as well. Some are designed for special purposes and/or private user groups while others are intended for general (public) use and interconnection to the PSTN. The later could support universal wireless communications.

One way to broadly categorize MSS systems is according to the orbital altitude of the satellites: geostationary satellites (GEOS), at an altitude of 35,786 km; low earth orbit satellites (LEOS), at altitudes on the order of 1,000 km; medium earth orbit satellites (MEOS), at altitudes on the order of 10,000 km; and highly elliptical orbit satellites (HEOS), with widely varying altitudes. GEOS systems for public use include INMARSAT-M, MSAT, ACTS, MOBILESAT, and NSTAR. LEOS systems include Iridium (66 satellites at roughly 770 km), Globalstar (48 satellites at 1400 km), and Teledesic (840 satellites at 700 km). Odyssey is a MEOS proposal with 12 satellites at about 10,600 km, and the ELMSAT proposal specifies a HEOS approach with two or three satellites.

2.5 FPLMTS (Future Public Land Mobile Telecommunication Systems)

The World Administrative Radio Conference (WARC) of the International Telecommunication Union (ITU), in March 1992, identified global bands 1885-2025 MHz and 2110-2200 MHz for Future Public Land Mobile Telecommunication Systems (FPLMTS), including 1980-2010 MHz and 2170-2200 MHz for the mobile satellite component.

The potential for all FPLMTS radio interfaces to be in the same frequency band world-wide provides a strong incentive to work towards ITU global standards which maximize radio commonality, in particular that between the satellite and terrestrial components of FPLMTS. This will simplify mobile equipment for operation in multiple FPLMTS radio operating environments.

FPLMTS are third-generation global systems that aim to unify the diverse systems we see today into a seamless radio infrastructure capable of offering a wide range of services, with the quality we have come to expect from the fixed telecommunications networks around the year 2000 in many different radio environments.

Third-generation mobile communications systems are one step beyond the digital cellular and cordless systems now coming into service, and will provide the capability to deliver voice, video, and data communications between people and/or machines anywhere -- anytime.

The first- and second-generation mobile systems we see today each only cover a limited range of radio operating environments so that a complex multimode mobile unit would be needed to ensure that one could really be reached anywhere -- anytime. Not only are the frequency bands and standards used by these earlier mobile systems different for the various environments, e.g., terrestrial, satellite, etc., but the range of services available and their quality are significantly less than those envisaged for FPLMTS.

The FPLMTS vision goes well beyond the individual capabilities of both wireless access and personal telecommunications.

Personal telecommunications involves providing an essentially transparent connection so that a practical range of "personalized" telecommunications services can be automatically provided to people on the move, wherever they may be. Both wired and wireless access can be involved, with existing infrastructures forming the basis for seamless call delivery to a person rather than a place.

The ITU concept of universal personal telecommunications (UPT) is based on the use of a personal number to allow communications with the network interface currently selected by the customer. This clearly complements the wireless mobility offered by FPLMTS radio networks giving the customer total mobility across many wired and wireless networks.

3 MOBILE MULTIMEDIA TERMINAL STANDARDS

There is considerable activity by the two primary international communications standards organizations [ITU-International Telecommunications Union, ISO-International Standards Organization] to develop standards defining a mobile multimedia terminal. The standards work is divided into the four sequential phases listed below and described in the following sections.

BASIC ARCHITECTURE FOR LOW BIT RATE MULTIMEDIA TERMINAL (H.324)- The ITU-T has recently completed a set of Recommendations defining a multimedia terminal for transmission at very low bitrates, but with particular emphasis for the PSTN [Public Switch Telephone Network]. Since the maximum PSTN transmission bitrate is 28.8 Kbps, this standard is directly applicable to the mobile application where the bitrate is equally restricted. The key standard which describes the integrated audiovisual terminal is H.324. Other standards in the set cover video coding [H.263], speech coding [G.723.1], communication protocol [H.245], and multiplex [H.223]. The H.324 terminal also includes the provision for the transmission of data (e.g. still picture, computer graphics) in addition to speech and video signals. ITU-T Recommendation T.120 defines the procedures for this "data" transmission.

EXTENSION OF H.324 TO THE MOBILE ENVIRONMENT- The ITU-T is actively developing new Recommendations to extend the H.324 set of standards to the mobile environment. The key aspect of this work is the adaptation of the H.324 standards for operation under the very poor transmission error conditions which characterize mobile communications.

DATA BASE ACCESS- One the most important applications of the mobile multimedia terminal is the access of information from a remote data base. Examples of data to be accessed include drawings, video clips, documents, photographs, etc. These non-conversational services ease some of the coding constraints (e.g. delay), but it necessitates the development of standards to command and control the remote data base server. Work is underway by ISO and the ITU to fulfil this requirement.

LONG TERM ACTIVITIES- The G.723.1 speech coding standard operates at bit rates of 5.3 and 6.3 Kbps and provides near toll quality. The ITU-T is working on a new Recommendation, with a target completion date of 1998, which will provide toll quality at 4.0 Kbps. The H.263 video coding standard provides a significant improvement in picture quality relative to the H.261 Recommendation which was established in 1990. The ITU-T and ISO have initiated a joint project to investigate advanced video coding to provide a significant improvement over H.263.

3.1 H.324; Terminal for Low Bitrate Multimedia Communication

In September, 1993 the ITU established a program to develop an international standard for a multimedia terminal operating over the public switched telephone network. A major milestone in this project was accomplished in November, 1995, when the ITU determined that the multimedia terminal Draft Recommendation H.324 was approved for ballot. It is anticipated that the standard will be fully approved in March, 1996. The H.324 terminal will have two principal applications: [1] a conventional videophone used primarily by the consumer, [2] a multimedia system to be integrated into a personal computer for a range of business purposes, for example, telecommuting.

The ITU has also approved the four major functional elements of the H.324

terminal to begin the ballot process; [1] G.723.1 speech coder, [2] H.263 video coder, [3] H.245 communication controller, [4] H.223 multiplexer. The quality of the speech provided by the new G.723 audio coder, when operating at only 6.3 kilobits per second, is very close to that found on a conventional phone call. The picture quality, produced by the new H.263 video coder, shows promise of significant improvement relative to many earlier systems. It is anticipated that these technical advances, when combined with the high transmission bit rate of the V.34 modem [28.8 kilobits/sec. maximum], will yield an overall audiovisual system performance which is significantly improved relative to earlier videophone terminals.

3.1.1 H.324 (Multimedia Telecommunications Operating Over the PSTN)

Recommendation H.324 defines a multimedia communication terminal (an H.324 terminal) operating over the Public Switched Telephone Network (PSTN). The H.324 document refers to other ITU Recommendations, illustrated in Figure 3.1, which collectively define the complete terminal. Four new companion Recommendations include: H.263 (Video Coding at Rates Less Than 64 kbit/s), G.723 (Speech Coder for Multimedia Telecommunications Transmitting at 5.3/6.3 kbit/s), H.223 (Multiplexing Protocol for Low Bitrate Multimedia Terminals), H.245 (Control of Communications between Multimedia Terminals). H.324 specifies use of the V.34 modem, which operates up to 28.8 kbit/s, and the V.8 (or V.8bis) procedure to start and stop data transmission. An optional data channel is defined to provide for the exchange of computer data in the workstation/PC environment. H.324 specifies the use of the T.120 protocol as one possible means for this data exchange. Recommendation H.324 defines the seven phases of a call: set-up, speech only, modem training, initialization, message, end, clearing.

3.1.2 G.723.1 (Speech Coder for Multimedia Telecommunications Transmitting at 5.3/6.3 kbit/s)

The G.723.1 Speech Coder can be used for a wide range of audio signals but is optimized to code speech. The system has two mandatory bit rates: 5.3 and 6.3 kbit/s. The coder is based on the general structure of the Multipulse-Maximum Likelihood Quantizer (MP-MLQ) speech coder. The MP-MLQ excitation will be used for the high-rate version of the coder. The Algebraic Codebook Excitation Linear Prediction (ACELP) excitation is used for the low-rate version. The coder provides a quality essentially equivalent to that of a POTS toll call. For clear speech, or with background speech, the 6.3 kbit/s mode provides speech quality equivalent to the 32 kbit/s G.726 coder. The 5.3 kbit/s mode performs better than the IS54 digital cellular standard. Performance of the coder has been demonstrated by extensive subjective testing. This coder encodes the audio signal in 30-msec. frames. In addition, there is a look ahead of 7.5 msec. Provision is provided to rapidly switch off the coder when speech is not present.

3.1.3 H.263 (Video Coding at Rates Less than 64 KBIT/S)

It is mandatory that the H.324 terminal have available both H.261 and H.263 video coding algorithms. The picture format will adhere to the principles listed below and illustrated in the following table.

decoding of both QCIF and sub-QCIF is mandatory;
when sub-QCIF pictures are encoded with H.261, the transmitted format is QCIF (black borders); when sub-QCIF pictures are encoded with H.263, the transmitted format is sub-QCIF;
the sub-QCIF picture format has the same pel aspect ratio as QCIF;
in case of H.261, the number of significant lines and pels/line is up to the manufacturer; in case of H.263, the sub-QCIF picture format is 128x96;
H.263 is mandatory for both the encoder and decoder of all GSTN-videophones, except an H.320 interworking adapter.

ALGORITHM
PICTURE FORMAT
FORMAT IN
BITSTREAM
MANDATORY/
OPTIONAL

ENCODER
DECODER

H.261
QCIF or SQCIF*

QCIF
QCIF**
Mandatory

H.263
QCIF or SQCIF
128x96
QCIF and SQCIF
128x96
QCIF or SQCIF
128x96
Mandatory for
Videophone--Optional for IWA

* Any number of lines, pels/line less than QCIF. Pels must have same aspect ratio as QCIF.
** SQCIF pictures are transmitted with black borders.

The H.263 coding algorithm is an extension of H.261. H.263 describes, as H.261 does, a hybrid DPCM/DCT video coding method. Both standards use techniques such as DCT, motion compensation, variable length coding and scalar quantization, and both use the well-known macroblock structure. Differences between H.263 and H.261 are:

Overlapped block motion compensation (optional)
Motion vectors pointing outside the picture (optional)
8x8 pel motion vectors (optional)
Syntax-based arithmetic coding (optional)
H.263 has an optional GOB level
H.263 uses different VLC tables at the Macroblock and block levels
H.263 uses half pel motion compensation instead of full pel plus loopfilter
in H.263, there is no still picture mode (JPEG is used for still pictures)
in H.263, there is no error detection/correction included like the BCH in H.261
H.263 uses a different form of macroblock addressing
H.263 does not use the end of block marker

Of particular interest is the optional PB-frame mode. A PB-frame consists of two pictures being coded as one unit. The name PB comes from the name of picture types in MPEG where there are P-pictures and B-pictures. Thus a PB-frame consists of one P-picture which is predicted from the last decoded P-picture and one B-picture which is predicted both from the last decoded P-picture and the P-picture currently being decoded. This last picture is called a B-picture because parts of it may be bidirectionally predicted from the past and future P-pictures. The prediction process is illustrated in Figure 3.2. It is anticipated that the H.263 system will typically outperform H.261 (when adapted for the PSTN application) by 2.5 to 1.

3.1.4 H.245 (Control of Communications Between Multimedia Terminals)

The H.324 terminal allocates one virtual communication channel for the supervision and control of the operation of the terminal. Recommendation H.245 (Control of Communications between Multimedia Terminals) defines the communication protocol for the use of this channel. Examples of messages which are defined include (1) capability exchange, (2) mode-setting, (3) status indication, (4) call control, (5) encryption, (6) maintenance. Provision is made for both point-to-point and multipoint operation. Recommendation H.245 creates a flexible, extensible infrastructure for a wide range of multimedia applications including storage/ retrieval, messaging, and distribution services as well as the fundamental conversational use. The control structure is applicable to the situation where only data and speech are transmitted (without motion video) as well as the case where speech, video, and data are required.

3.1.5 H.223 (Multiplexing Protocol for Low Bitrate Multimedia Terminals)

Figure 3.3 is a functional block diagram of the H.223 Multiplexer illustrating a two-layer structure. The Adaptation Layer (AL) provides the interface between the individual virtual channels (video, speech, data, control) and the multiplex layer. The adaptation layer supports the underlying MUX layer and the next higher application layer. One of the most important functions performed by the AL is error control. In the case of video, the AL3 employs a retransmission strategy. The AL1 for the H.245 control channel is implemented using the V.42 LAPM protocol. Variable length packets are generated by the multiplex layer for transmission. This multiplex structure is particularly advantageous for adapting to the mobile radio environment which requires extraordinary error control procedures.

3.2 H.324M; Mobile Multimedia Terminal

The ITU-T has initiated a program to adapt the H.324 set of Recommendations [which define a multimedia terminal for PSTN operation] for transmission over mobile networks. The new mobile multimedia terminal is designated as H.324M.

Figure 3.4 illustrates the general structure of the H.324M mobile multimedia terminal which is clearly in the process of evolution and development. Work toward the H.324M Recommendation has been divided into the following areas of study; [1] speech error protection, [2] video error protection, [3] communications control [adjustments to H.245], [4] multiplex/error control of the multiplexed signal, [5] system. Items 1, 2, and 4 are the most complex areas requiring the most work, and considerable progress has been made as outlined in Table 3-1.

The general principles and underlying assumptions upon which the H.324M Recommendations are to be based are listed below.

1. H.324M Recommendations should be based upon H.324 as much as possible.

2. The technical requirements and objectives for H.324M are essentially the same as they are for H.324.

3. Since the vast majority of mobile terminal calls are with terminals in fixed networks, it is very important that H.32M Recommendations be developed which maximize interoperability with these fixed terminals.

4. It is assumed that the H.324M terminal has access to a transparent/ synchronous bit stream from the mobile network.

5. It is proposed to provide the manufacturer of mobile multimedia terminals with a number of optional error protection tools to address a wide range of mobile networks; regional and global, present and future, cordless and cellular. Consequently H.324M tools should be flexible, bitrate scaleable, and extensible to the maximum degree possible.

6. Like H.324, non-conversational services are an important application for H.324M.

Table 3-1 H.324M Work Plan

H.324M FUNCTION
WORK PLAN
5/96
ACTION

Speech Error
Protection
- Annex C of G.723; Successfully determined at 11/95 SG15 meeting;
- "Scaleable Error Protection for G.723"
- includes Unequal Error Protection (UEP)
Decision

Video Error
Protection
- ARQ is valuable (inherent in H.223)
- error concealment is very important (TCON)
- UEP is temporarily rejected; error protection improvement may not justify added delay; further study
- scaleable FEC/interleaving is possible addition
- H.263 GOB segmentation is promising modification to H.263
Determination

Communication
Control
Add code points to H.245
Determination

Multiplex
Compare two alternatives:
1. Add error protection to the H.223 bitstream; EEP or UEP; possible retransmission (would result in Annex to H.223).
2. A new multiplex structure (AV.22M); requires a new Recommendation specifically for mobile.
Determination

System
Annex to H.324
Determination

VIDEO - Considerable progress has been made toward the application of error control to the H.263 signal. Technology which appears particularly promising, includes ARQ, GOB segmentation, and error concealment. Work is also underway to determine the value of scaleable FEC/Interleaving for protection of video errors.

The application of Unequal Error Protection (UEP) to H.263 in a mobile environment has been studied extensively. A gain of approximately 2 dB in SNR can be obtained. The main disadvantage of the UEP is that the information of one frame must be stored for error protection processing. This causes one frame delay. UEP is temporily rejected since the disadvantages of the delay outweight this 2db improvement.

ARQ has been justified to be an important part of video error protection.

An error concealment alogorithm (TCON) that uses the H.263 unchanged, has been found to greatly improve the picture quality and is considered an absolute necessity.

Several core experiments with ARQ have been performed. The most advanced proposal is to use sub-videos with re-transmission and intra refreshing. The GOB boundaries are treated as picture boundaries. This provides a considerable improvement in picture quality.

It has decided that error control for video may include a hybrid FEC/ARQ scheme. It is intended to provide a complete technical solution for video error control including ARQ, and potentially a flexible FEC/interleaver. The video error control will be flexible to be adapted to a range of mobile networks.

SPEECH **-** It was agreed to use the G.723.1 speech coder for the H.324 terminal, but it is also agreed that additional error protection is required for the mobile environment. At the November, 1995 meeting, the ITU-T selected a particular approach for protecting the G.723.1 signal and has designated it to be included as Annex C of the speech coder standard. Unequal error protection is employed by classifying the coded bits into 5 levels of error sensitivity.

A rate 1/3 convolutional channel code is used as the mother code for rate compatible punctured convolutional coding (RCPC). The system is automatically scaleable by bit rate so that the ideal error protection is applied regardless of the application bit rate (cellular, cordless or regional network, etc.).

MULTIPLEX**-** Two multiplex alternatives are being compared; [1] the addition of error protection to the H.223 bitstream, [2] a new multiplex approach based on a totally new system design.

COMMUNICATION CONTROL**-** Code points necessary for H.324M operation are being added to H.245 to provide for the necessary mobile operations.

SYSTEM**-** An Annex to H.324, defining the H.324M system, is being prepared which outlines the overall system structure of the mobile multimedia terminal.

3.3 T.120 **-** Graphic Communications For Multimedia Terminals

The ITU-T has developed, and continues to expand, the T.120 set of Recommendations which addresses a wide range of multimedia applications. Basically it provides the means to communicate the graphics segment [still pictures, computer graphics, white board, etc.] of a multimedia conference. The T.120 standard is specified in both the H.324 and H.324M multimedia terminal Recommendations as the optional way to transmit a wide range of graphics data in combination with the speech and/or video signals.

The T.120 series of Recommendations is composed of a communications infrastructure and application protocols that make use of it. Figure 3.5 shows the full model with both standardized and non-standardized components. The model serves both to show the scope of the T.120 suite of recommendations and the relationship between each of the recommendations and other elements in the system. Generally, each layer provides services to the layer above and communicates to its peer(s) by sending Protocol Data Units (PDUs) via services provided by the layer below.

COMMUNICATIONS INFRASTRUCTURE

The communications infrastructure, illustrated in Figure 3.5 , provides simultaneous Multipoint connectivity with reliable data delivery. It can accommodate multiple independent applications concurrently using the same Multipoint environment. Connections can be any combination of circuit switched telecommunications networks and packet based LANs and data networks. It is composed of three standardized components: Generic Conference Control (GCC), the Multipoint Communications Service (MCS) and Transport Protocol Profiles for each of the supported networks. Adding GCC provides a range of facilities oriented to the use of MCS in an electronic meeting or conferencing but believed to be generally useful for other Multipoint communications requirements.

APPLICATION PROTOCOLS

Application protocols comprise a set of PDUs and associated actions for application peer-to-peer(s) communication. These may be proprietary protocols or they may be standardized by the ITU-T or other international or national standards bodies. The T.120 series includes a set of application protocols designed to support common facilities for graphic communication. These protocols define and mandate a minimum requirement in order to ensure interworking between different implementations, and include facilities for simultaneous file transfer (T.127) and audiographics protocols for still image viewing and annotation, application sharing and fax (all provided in T.126). See below.

Rec. T.126 - Still Image Exchange and Annotation (SI) - T.126 defines a protocol for viewing and annotating still images transmitted between two or more applications. This capability is often referred to as document conferencing or shared whiteboarding.

An important benefit of T.126 is that it readily shares visual information between applications that are running on dramatically different platforms. For example, a Windows-based desktop application could easily interoperate with a collaboration program running on a PowerMAC. Similarly, a group-oriented conferencing system, without a PC-style interface, could share data with multiple users running common PC desktop software.

Rec. T.127 - Multipoint Binary File Transfer Protocol - This Recommendation defines a protocol to support the interchange of binary files within an interactive conferencing or group working environment where the T.120 series of standards is in use. it provides mechanisms which facilitate distribution and retrieval of one or more files simultaneously.

3.4 Video Server/Database Access

One of the most important applications of the mobile multimedia terminal is the access of imagery [still pictures, video clips, computer graphics, etc.] from a remote database. Typical uses include remote diagnostics/maintenance/repair, sales presentations, workers on travel, access of drawings at a construction site, access of information in an emergency [fire, police, eathquake, terrorism, etc.].

The ITU-T and ISO are developing standards to address this requirement which is generally known as non-conversational services. The ISO has developed the DSM-CC [Digital Storage Media-Command/Control] standard which is part of the MPEG family of video coding standards. It is anticipated that this standard will be used in the future consumer set-top entertainment TV environment.

The previous Section 3.3 descibed the T.120 set of ITU-T Recommendations which may be used to access imagery from a remote database. Work continues to expand the T.120 Recommendations to provide for potential use to access remote data bases.

3.5 Advanced Video/speech Coding

ADVANCED VIDEO CODING

The recently developed H.263 video coding standard provides a signficiant improvement in picture quality for operation over very low bitrate networks such as the PSTN and the mobile environment. However, it is generally agreed that, for these very low bitrate applications, it is desirable to try to develop a more advanced coding algorithm which improves upon H.263. The ITU-T and ISO international standards organizations have both initiated long range programs [targeted completion date of 1998] to address this requirement. The ITU-T program addresses applications for both conversational and non-conversational services. Objectives include lower delay, higher compression, improved quality, robust operation in error-prone environments, and reduced complexity.

The ITU-T is working jointly with ISO/MPEG4 to develop advanced video coding technology having features beyond the normal frame-based "waveform" coding concepts such as DCT, fractals, vector quantization, wavelets, etc. Examples of these advanced features include [1] the establishment of foreground/background layers, [2] stereo coding, [3] object based coding [4] hybrid coding of natural and synthetic images, [5] coding of computer-originated video sequences based on three-dimensional models, [6] new video coding language to be possibly downloaded prior to transmission.

ADVANCED SPEECH CODING

The recently developed G.723.1 speech coding Recommendation provides a significant improvement in speech quality at very low transmission bitrates--5.3 Kbps and 6.3Kbps. The ITU-T has initiated a project to develop an even more advanced speech coder to provide toll quality at 4.0 Kbps. This coder, which is due for completion in 1998, will contribute greatly to the overall performance of the mobile multimedia terminal.

4 IMPLEMENTATION OF MOBILE MULTIMEDIA TERMINALS

The purpose of this section is to provide an overview of the status of the development of wireless multimedia terminals. The discussion is divided into the four parts listed below and presented in the following subsections.

MAVT PROJECT- For several years, the European Union has funded the RACE [Research in Advanced Communications in Europe] program, one part of which is directed toward the development of the MAVT [Mobile Audio-Visual Terminal]. Considerable resources have been allocated to this effort, and the work merits particular attention.

H.324 VIA AMPS- The mobile AMPS [Advanced Mobile Phone Service] network is a very large analog voice network which can be likened to the PSTN in function and operation. It is therefore reasonable to consider the direct application of the H.324 terminal [designed for the PSTN] for use on the mobile AMPS network.

PORTABLE GENERAL PURPOSE COMPUTERS- By far the most promising, and most immediate, version of wireless multimedia terminals will use portable general purpose computers. These devices have many inherent advantage; low cost, large high quality displays, high level of processing power, portability.

SPECIAL PURPOSE PRODUCTS- Some work has begun on the development of specific multimedia products for mobile networks.

4.1 Investigations in Europe

The objective of the European RACE/MAVT project is to develop video and audio coding algorithms for the transmission of moving and still video in a mobile environment. A brochure summarizing the MAVT program and its achievements is included in Appendix 4A. Major accomplishments of the MAVT program are listed below.

- 1992 to 1993: analysis of network characteristics; development of video and audio coding algorithms.

- 1994 to 1995: development of a demonstrator based on a desk-top PC with six special PC cards. The demonstrator provides bidirectional transmission of video and speech over a DECT [Digital European Cordless Telecommunication] network. The DECT bitrate is 32 Kbps, with the video occupying 24 Kbps and the speech 8 Kbps. Demonstrations have been successful proving the feasibility of multimedia via mobile networks.

- 1995: developed the design of a pocketsized multimedia terminal called "Handy".

4.2 H.324 Via AMPS

There are over 10 million subscribers to AMPS, and the network continues to grow rapidly. Since the network can be viewed as an analog PSTN network, it is reasonable to consider using the H.324 terminal directly on the AMPS network. One important advantage of this concept is the elimination of the interworking adapter at the interface between the cellular and PSTN networks which would be otherwise required to convert between the H.324 and H.324M signals. In this way a typical call from a user on a mobile network to a user on the PSTN could be readily accomplished with a minimum of distortion. A number of experiments, with both V.32bis and V.34 modems transmitting over the AMPS network, have been undertaken with very promising results.

To enhance the performance and reliability of cellular-modem communications, a number of modem manufactures have announced their support of MNP 10EC cellular modem technology. The MNP 10EC algorithm deals with cellular impairments such as cellular-bases-station handoffs, dropouts, interference, fading, and echoes to improve overall connectivity. The improvement is accomplished by packetizing the data stream using a V.42-like structure with the ability to rapidly change packet size based upon link conditions. The problem with this approach is that it is possible to add a large delay which can make interactive communications difficult. Work is underway by the modem community to modify the protocol to reduce this problem. Of course, the existing protocol is ideal for non-conversational access to data bases which is very important for mobile audiovisual applications. A press announcement deals with the MNP 10EC development is included in Appendix 4B.

Appendix 4C includes brochures on cellular modems which are configured for a PCMCIA interface to a notebook computer. This type of device permits existing laptop computers to be used for videoconferencing applications today. The notebook computer could communicate over the AMPS mobile network to a desktop personal computer containing the same type of cellular modem. Since many of the important elements of a teleconference system are available in all-software form it now feasible to field a notebook videoconferencing system communicating over the ubiquitous AMPS mobile network.

4.3 Portable General Purpose Computers

The advent of very high performance portable computers has made mobile wireless video teleconferencing systems practical today. A wide range of portable computers exists ranging from notebooks to tablets to palm-sized devices. The notebooks and tablets have ports for PCMCIA cards which have a wide range of functionality for mobile network applications. The processing power of these laptop and tablet computers has recently exploded. Pentium power is available on notebooks, and Appendix 4D includes a brochure on a Fujitsu tablet powered by an Intel486 DX-50 microprocessor. In addition, the quality of the displays on these devices is radically improving. Finally the power of software-only implementations of video conferencing systems continues to improve. The simultaneous availability of all of these technologies makes mobile wireless VTC systems practical today.

The IBM ThinkPad series [Power series 850], described in Appendix 4E, is particularly interesting for mobile videoconferencing applications. An optional TV camera clips to the computer making it suitable as a source of VTC as well as a high quality display device. PCMCIA cards are also available to provide the interface between a video camera and a notebook computer. One example of such a device is included in Appendix 4F.

4.4 Special Purpose Products

Research has begun on the development of special purpose terminal devices for mobile videoconferencing applications.

For example, Matsushita/Panasonic has announced, and demonstrated, a new wireless VTC product which is illustrated in Figure 4.1. A press release describing the device in some detail is included in Appendix 4F. Features of the system are listed below.

- operates over 32kbps cordless transmission channel
- video coding using H.261 via ARQ retransmission capability
- 2.5-inch color LCD screen
- speech coding by G.721
- QCIF resolution
- Frame rate - 3-7 frames/sec.

There is no question that the union of three of the most explosive technologies--computers, mobile communication, video--will occur quickly, and the result will provide an extremely valuable facility for the federal government community.

5 APPLICATIONS OF MOBILE MULTIMEDIA TERMINALS

Wireless communications is a technology in which it seems the applications are limited only by the imagination. This statement may have been applied to other technologies previously but recent developments in the areas of wireless communications and personal communications have shown its validity particularly since it applies directly to the individual as well as to large organizations. For example, one aspect of wireless communication, Personal Communication System (PCS), is defined as the system by which every user can exchange information with anyone, at any time, in any place, through any type of device, using a single personal telecommunication number.

Of particular interest are the wireless applications involving imagery communication. Presently, for most applications of imagery communications, the terminal is a fairly large device which contains the communication interface, video processing and compression/decompression circuitry, image storage, and the display and operates over conventional common carrier channels. The development in the areas of wireless communications; such as cellular, terrestrial mobile, satellite, and cordless have provided freedom from the confines of hardwired communication channels. In addition, the high speed microprocessors and the portable and lap top computers in which they reside together with video application software has totally changed the concept of the imagery communications terminal. The terminal concept has also expanded to include mobile, portable, and even hand-held applications.

The following is a tabulation of some of the applications of wireless video terminals. The examples should be considered as generic and representative of a much larger field of applications.

1) TELECONFERENCING

Intra-complex teleconferencing without a hardwired LAN; The use of a wireless communication channel permits the terminal to relocate within an office complex without the need to rewire the cable plant. In fact, the terminal can roam from one application to another very efficiently. This technology can be implemented as a functional LAN and is often referred to as WLAN (Wireless LAN).

Intra/city teleconferencing without fixed cable plant; The same philosophy applies to relocation within a city. For example, city governmental functions can relocate, or roam as required in the performance of their function. This may be particularly suitable for emergency road crews, police, and fire protection. Legal requirements such as judge-suspect interviews, arraignments, etc., can be conducted very expeditiously without requiring either to be transported to a common location.

2) EMERGENCY/DISASTER SITUATIONS

Disaster recovery or any civil or natural emergency requires timely information transfer in both directions: site to headquarters and return. Video of the disaster area is needed by headquarters in order to properly allocate resources to the locations where they are most needed. Seldom are the proper communications circuits available; in fact, natural disasters generally decimate the lines of communication. Wireless radio systems have supported such communications for years. Now video systems utilizing wireless transmission can greatly enhance the flow of necessary pictorial information. The reverse path is just as critical. Headquarters can provide pictorial, map, graphic information, and computer data to the site, thereby greatly improving the quality and depth of information available to the personnel.

Situations as simple as traffic jams can be controlled more efficiently with the aid of wireless video. Pictures from the site of the congestion or the cause of the congestion can be transmitted to a central control point or to locations at which contributing traffic can be controlled to minimize additional congestion and to provide relief routes for the traffic.

This same approach applies to fire disasters. Pictures of the disaster and the action being taken for its control can be transmitted to a central control point. In addition, the pictures can generated at hazardous and otherwise inaccessible points to provide the most useful information

3) TELEMEDICINE

Medical records, in particular X-rays, are often stored in central locations, many in hardcopy form. They need to be accessed by doctors on a temporary basis. The use of wireless video transmission can greatly shorten the information transfer time and eliminate the effort required for the physical transport of such records to the doctor and their return to the central file .

Medical records are often needed in the field. A large medical service is provided by remote health workers in the field who travel to provide health services. They also need to access their patients's health records which may be stored at the host hospital. A wireless video link can provide this function. At an even higher level, these same health workers need to provide pictorial information including physical views of patient's injured areas and X-rays to the doctors at the host hospital in order to obtain their diagnosis.

4) LAW ENFORCEMENT

An application of wireless video transmission in the area of law enforcement (which has been experimentally implemented) is reading license plates at opportune locations. The video is transmitted by radio to a location where the data is compared to a data base for various reasons. Since the system is not confined to a single location by hardwired communications circuits, it can relocated readily.

In many areas, police vehicles are equipped with radio facsimile devices to provide visual communications to the officer of records of vehicles or of persons apprehended, as well as general information from the central data base. In some cases a reverse service permits transmission of pictures, license, or registration data from the vehicle to headquarters.

5) PERSONAL/COMMERCIAL NAVIGATOR

Being lost while driving in an unfamiliar area or finding a road blocked and being required to take a strange road as a detour is a quite common occurrence. Techniques have been developed to provide a visual map type display to the vehicle via a wireless channel. Maps, of course, have limitations in that it may be difficult to quickly correlate them with the vehicle's surrounding while in motion. Pictures of key landmarks transmitted to the vehicle can be a great aid in becoming oriented and reaching the destination. Evaluation systems have been implemented but without the benefit of pictorial input.

An application which has been pursued with only moderate success to date using other techniques is transmission of video information about the movement of a mobile platform to that platform from a fixed environment. Docking a ship in a congested harbor can greatly be simplified by televising the progress of the ship through the congested area into the dock from the dock point of view and transmitting that sequence of motion images to the bridge of the ship. Shifter engine movement in a freight yard while assembling a train is a very similar application. In addition it can provide the engineer with the ability to verify the identification of a car by reading the ID label from the side of the car before attaching the next car. Tractor trailer truck drivers docking within the very tight confines of a typical docking area would benefit from images of their progress. Similarly, pilots of aircraft maneuvering to get to the loading ramp at a busy terminal would greatly benefit from seeing their relationship to other aircraft.

6) ENGINEERING/MAINTENANCE

Engineering data in addition to the normally available drawings may be required at a field construction, maintenance, or remote assembly area. Wireless video transmission of pictures, picture sequences, or computer based drawings can expedite problem resolution. Although drawings are often complex, ability to browse through a drawing (viewing a segment) can eliminate the need for extremely high resolution terminals and minimize transmission time. Other relevant image data includes parts list, exploded views, photographs, and even picture sequences of assembly, disassembly, and repair. Conversely, pictures transmitted via a return video wireless link can provide the image information to help headquarters personnel to solve field problems.

7) ELECTRONIC NEWS GATHERING

The news media, both newspapers and television, are highly competitive to get the news to the public as quickly as possible. Several techniques are in use but provide only still pictures or moving pictures at comparatively great expense. Wireless video can be implemented in a small inexpensive unit to provide instant still and motion pictures at low cost to the media. The size/cost factor will permit many employees to be equipped with units. Even non-employees could transmit pictures to the media much as vocal news information is presently acquired by wireless telephone.

8) REAL ESTATE

Real estate agencies and multiple listing agencies can develop catalogs of motion picture information about their listings. Wireless video can be used by the agent to generate a walk through and walk around sequence of the property on the first visit and transmit it to the central office by wireless for incorporation into the catalog.

Conversely, the agent at a potential customer's location, can access the central catalog and display motion sequences of selected properties to determine client interest.

9) REMOTE CONTROL

Many industrial applications can benefit from remote viewing and wireless transmission systems. Observation of a dangerous area or an area which has a difficult environment can be viewed by an observer in a safe, benign environment. When these situations arise there is often not enough time to procure the proper circuits for video transmission, and wireless systems are ideal. Difficult operations can benefit from wireless video displays. For example, loading supplies into the hold of a ship can be greatly facilitated if the loading control manager can personally view pictures of selected areas of the cargo hold to determine the amount of space available and its precise location and type of supplies stored there.

10) SURVEILLANCE

Casinos can benefit from wireless video transmission in that cameras can be located and quickly relocated to observe areas of particular interest. Trial systems have been successfully implemented.

In general, wireless video transmission is very applicable to surveillance applications. In many situations, an area needs to be observed only for a relatively short interval of time, e.g., a few hours or a few days. The camera and transmitting equipment must then be dismantled, stored, or relocated. Communications circuits are generally not available at these random locations and are expensive to implement. Furthermore, a substantial period of time would be required for their installation. Neither of these conditions are tolerable for many surveillance applications making them ideal candidates for the use of wireless video. One example is repair of oil or gas pipeline damage. This damage generally creates an environment dangerous to repair workers and to residents of the area. By the use of wireless video, the progress can be observed by management personnel, experts in pipeline repair, and personnel responsible for flow through the pipeline.

Recently a wireless video unit (which does not incorporate any of the standards) has been put on the market to provide remote baby sitting. The camera views the sleeping child and transmit the picture to the parents or baby sitter who may be at a neighbor's house.

11) FACSIMILE

This is an area of wireless video communications which is already being exploited. One example of wireless facsimile as utilized by the police was described above. Personal facsimile capability has also been incorporated into wireless handheld devices (e.g., IBM's Simon) in addition to functioning as a multi-capability personal communication device. The application of facsimile utilizing these devices is extensive; e.g., salesmen obtaining sales material, field crews obtaining engineering data, etc.

12) COMPUTER VISUAL COMMUNICATION

Perhaps the greatest immediate concentration on wireless communication, which also utilizes video displays, is in the field of personal computer communications. These devices extend the computer to the field with the ability to access home office or other remote data bases. Several manufacturers have developed products which are being marketed. Other major corporations are developing products, forming alliances to combine capabilities (particular hardware and software) for this application.

These products fall into several categories: personal communicators, personal information processors, personal digital assistants, and personal intelligent communicators. In general they provide combinations of features from pen-based computers, cellular phones, electronic mail, speech and handwriting recognition, still image, full motion video, and video teleconferencing. Incidentally they may combine other features such as calculators, two-way pagers, calendars, appointment schedules, facsimile, and a full range of computer capability.

6 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are drawn from the work performed on this project.

- Wireless communications [cellular, cordless, wireless LANs, satellite] is undergoing a revolutionary change from analog to digital technology. This digital orientation will greatly facilitate the application of multimedia communications to the mobile environment.

- The ITU is developing a set of standards [H.324M] for a mobile multimedia terminal [to be completed in 1996] which will be applicable to a wide range of mobile networks. The advent of the H.324M standard will be key to the development of practical inexpensive wireless videoconferencing.

- Wireless multimedia terminals are practical today due to the advent of very high performance portable computers such as Pentium notebooks, tablets, and palm-sized devices, as well as software implementations of videoconferencing systems such as H.320 and H.324.

- The federal government will greatly benefit from the development of mobile multimedia terminals. Applications include teleconferencing, remote maintenance/diagnostics, disaster relief, and surveillance.

It is recommended that the following actions be undertaken to insure that the potential for mobile multimedia communications throughout the federal government community is fully realized.

- Support the domestic and international standards activities which are underway to develop Recommendations for wireless networks and mobile multimedia terminals [H.324M].

- Demonstrate the power of existing notebook computer technology and mobile networks to provide teleconferencing capability within the federal community today.